

**WIDE RANGE
ULTRA-LOW FREQUENCY
OSCILLATOR**



Model 410-A

KROHN-HITE INSTRUMENT COMPANY

CAMBRIDGE 39, MASS., U. S. A.

RECENT REVISIONS

TECHNICAL SUMMARY

FREQUENCY ACCURACY: Change - "Calibration $\pm 4\%$ " to "Calibration $\pm 2\%$ ".

INSTALLATION AND OPERATION

Second Paragraph - add the following sentence at the end:

The Model 410-A housed in a metal dust cover cabinet will fit directly into a rack panel.

MAINTENANCE - Last Paragraph, 5th line should read:

Although the 6AS7, 5V4 and 6AQ5 tubes are rigidly clamped to the chassis it is possible for them or some of the smaller tubes to be loosened in shipment.

MAINTENANCE - After Last Paragraph add:

Figure 11 provides a tabulation of approximate ohmmeter readings across some of the resistors in the circuit. These readings include the parallel paths through other resistors and are to be checked without disconnecting any leads or components. The resistors are listed in order of their location from front to back on the terminal boards. Refer to Figures 7, 8, and 9.

PARTS LIST - Change $\pm 1\%$ to $\pm 5\%$ on the following:

R108, R109, R152, R153, R203, R204, R207, R209, R211, R218, R406, R408, R452, R458, R460, R468, R469, R470, R471, R472, R505, and R506.

Change - R152, R153, R203, and R204 from 90,000 ohms to 91,000 ohms

Change - R211 from 480,000 ohms to 430,000 ohms

Change - R429 and R430 from 1/3W to 1/2W

Change - R452 from 3,950,000 ohms to 3,600,000 ohms

Change - R458 and R506 from 480,000 ohms to 510,000 ohms

Change - R459 from 470 ohms 1,500 ohms

Change - R460 from 9,000,000 ohms to 8,200,000 ohms

Change - R467A-G to R467A-H

Change - R469 from 2,500 ohms to 2,400 ohms

Change - R470 from 11,100 ohms to 11,000 ohms

Change - R552 from 680,000 ohms to 620,000 ohms

Change - R628 and R629 from 527,000 ohms to 480,000 ohms

Change - C332 and C333 from 0.01mf 400V to 0.25mf 200V

Change - C402 from 21mmf to 39mmf

Change - C455 from 3.9mmf to 3.6mmf

RECENT ADDITIONS

RESISTANCE READINGS ACROSS RESISTORS INCLUDING PARALLEL PATHS

Conditions: Dial at 20, Band Switch on X 1000, ON-OFF switch off.

No External Connections to the Instrument.

BOARD Number	CIRCUIT Number	APPROXIMATE Ohms Reading
1	R462	790,000
1	R461	750,000
1	R457	200,000
1	R508	750,000
1	R509	790,000
1	R501	9,000
1	R502	9,000
2	R628	240,000
2	R629	240,000
4	R420	4,000
4	R425	750
5	R323	17,000
5	R322	110,000
6	R335	3,300
6	R318	3,000
6	R317	77,000
7	R105	1,200
7	R104	1,300
7	R361	4,000,000
7	R351	430,000
7	R356	4,000,000
7	R357	4,000,000
7	R352	450,000
7	R353	530,000
7	R358	4,000,000
8	R111	260
8	R113	440
9	R214	790,000
9	R213	750,000

FIGURE 11

W I D E R A N G E

ULTRA-LOW FREQUENCY

OSCILLATOR

Model 410-A

INSTRUCTIONS

Manufactured by

KROHN-HITE INSTRUMENT COMPANY

CAMBRIDGE 39, MASS., U. S. A.

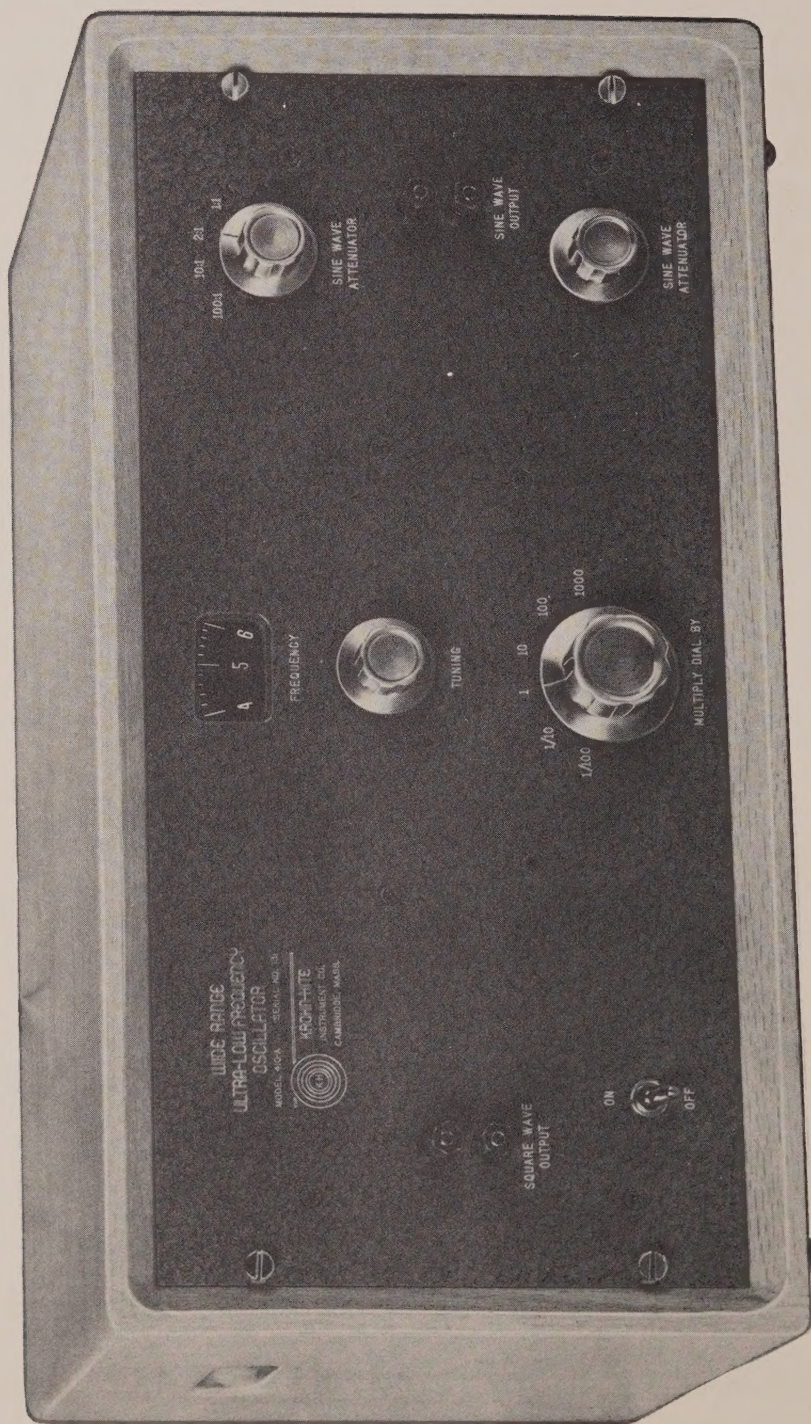


FIGURE 1 - MODEL 410-A ULTRA-LOW FREQUENCY OSCILLATOR

**WIDE RANGE
ULTRA-LOW FREQUENCY OSCILLATOR
MODEL 410-A**

TECHNICAL SUMMARY

POWER REQUIREMENTS:

SOURCE 105-125 volts, 50-60 cps
CONSUMPTION 150 Watts
FUSE PROTECTION 2 amperes (slo-blo)

FREQUENCY DIAL: Calibrated logarithmically from 1.8 to 22, controlled by a 5/1 vernier.

FREQUENCY RANGE: 0.02 to 20,000 cps.

Band	Multiplier	Frequency
1	1/100	0.02 - 0.20
2	1/10	0.2 - 2.0
3	1	2.0 - 20
4	10	20 - 200
5	100	200 - 2,000
6	1,000	2,000 - 20,000

FREQUENCY ACCURACY: Calibration $\pm 4\%$, drift including initial warm-up is less than 1%, drift with $\pm 10\%$ change in line voltage is less than $\pm 0.01\%$.

SINE WAVE OUTPUT:

VOLTAGE: 5 volts rms. maximum, adjustable continuously by a T-pad, and in steps by a switch providing attenuation ratios of 100:1, 10:1, 2:1 and 1:1

IMPEDANCE: 500 ohms

AMPLITUDE: Varies less than ± 0.25 db (3%) over the frequency range from 0.02 to 20,000 cps.

DISTORTION AND HUM: Less than 0.25% over the frequency range from 0.02 to 20,000 cps.

SQUARE WAVE OUTPUT:

VOLTAGE: 10 volts peak to peak $\pm 5\%$

IMPEDANCE: 5,000 ohms

SUB-SONIC RECOVERY TIME: Recovers to 90% of its steady state amplitude in less than 3 cycles of the dial frequency, after band-switching, tuning, or similar disturbance.

FORM: Standard Rack Panel 19" x 8-3/4", 12" deep, overall dimensions 21" wide, 11" high, 13" deep, weight - 50 lbs.

TUBE COMPLEMENT: 14-12AX7, 8-6AL5, 5-12AU7, 3-12AT7, 2-6AQ5, 1-6AS7, 1-5V4, 1-5651(VR).

DESCRIPTION

The Model 410-A Wide Range Ultra-Low Frequency Oscillator, shown in Figure 1, is a reliable source of sine or square waves at any frequency between 0.02 and 20,000 cycles per second. This instrument is completely electronic and easily portable. It operates from an AC source of 105 to 125 volts, 50 to 60 cycles per second. An integral power supply furnishes the heater voltages and the regulated DC voltages required for operation.

Figure 2 shows the essential units of the Oscillator in block diagram form. The network section contains the frequency determining parameters, which are selected by the frequency dial multiplier switch. A modified RC bridge type circuit is used as the frequency determining network. The main and subsidiary amplifiers provide the required signals for the bridge elements. The frequency control is a single tapered precision potentiometer, which varies the amount of the signal voltage applied to one of the bridge elements. The sine wave output is maintained very nearly constant by controlling the amount of the signal voltage applied to another element in the bridge via the AVC system.

An output circuit is used as a buffer to isolate the oscillator and provide a low source impedance for the sine wave output. The output signal is maintained very nearly constant by the AVC control system. This system consists of the phase reversal circuit, phase shift circuit, gate circuit, "boxcar" detector, AVC amplifier, balanced modulator and fast recovery circuits. A phase reversal circuit is used to obtain balanced two-phase performance for fast recovery. The phase shift and gate forming circuits provide triggers for the "boxcar" detector, which is used to obtain low distortion and improved AVC stability. After sufficient amplification, the phase shift circuit signal is used for the square wave output. The AVC error voltage from the "boxcar" detector, after amplification and filtering, is employed

to control the balanced modulator which provides a signal to the network, controlling the sine wave output amplitude. The AVC amplifier also controls the fast recovery circuit, normally biased off, but switched in after a transient disturbance, such as band-switching and tuning, to hasten the rate of build up and decay of the sine wave amplitude at low frequencies.

A potentiometer, ganged with the main frequency control is used to maintain the proper recovery gain at all frequencies.

The step switch attenuator and sine wave amplitude T-pad attenuator are cascaded directly on the output circuit to maintain hum and distortion in constant ratio to the output sine wave voltage.

INSTALLATION AND OPERATION

The Model 410-A Wide Range Ultra-Low Frequency Oscillator is carefully packed and completely checked prior to shipment to insure that you receive an instrument that is ready for operation. It is easy to operate and requires no initial warm-up period or adjustments.

For rack panel mounting it is necessary to remove the four thumb screws on the front panel and the machine screw at the bottom rear of the cabinet. When removed from the cabinet the Oscillator is more susceptible to pick-up and some precautionary measures, such as shielding or relocation, may be necessary.

There are only four front panel controls.

THE TUNING control selects the output frequency as read on a single scale, illuminated dial which is engraved logarithmically from 1.8 to 22 and calibrated directly in cycles per second.

THE FREQUENCY DIAL MULTIPLIER switch selects the proper multiplying factor for all the six bands, each of which covers a frequency range of 10 to 1 with 10% overlap.

THE SINE WAVE AMPLITUDE control is a 500 ohm T-pad attenuator which adjusts the level of the sine wave output.

THE SINE WAVE ATTENUATOR switch provides convenient attenuation ratios of 100:1, 10:1, 2:1 and 1:1 when precise output voltage increments are required.

SUB-SONIC OPERATION

Rapid recovery from transients, such as band-switching and tuning, are inherent in the design of the instrument. However, the waiting time required for the output voltages to reach their steady state amplitude on the lowest band can be appreciably reduced by use of the procedure illustrated in the following examples:

When the Oscillator is first turned on for band 1 operation (0.02 to 0.2 cps), the waiting time required for the output amplitude to reach 90% of the steady state value may be 3 cycles of the dial frequency plus the time required to initiate electron emission in the vacuum tubes. If the desired frequency is 0.02 cps this total delay time may amount to more than 150 seconds. This type of delay which is inherent on band 1 can be reduced appreciably by the following procedure:

- (a) Set FREQUENCY DIAL MULTIPLIER switch to band 2.
- (b) Set TUNING dial to desired frequency.
- (c) Wait for recovery to nearly steady state operation (waiting time is approximately $1/10$ the time required on band 1).
- (d) Then switch to band 1.

Tuning transients on band 1 also may require 3 cycles waiting time for the output amplitude to reach 90% of the steady state value. For example, if the frequency is initially set at 0.05 cps and you tune to 0.02 cps, the delay in the output amplitude reaching 90% of the steady state value may

again be nearly 3 cycles of 150 seconds. This delay can be overcome in a similar manner by first switching to band 2, then tuning to 2 on the dial frequency, waiting for recovery, and then switching to band 1.

Essentially you are taking advantage of the fact that 3 cycles on band 2 are shorter in time than on band 1 and that the circuits are so arranged that only a slight transient disturbance is caused by switching from band 2 to band 1.

MAINTENANCE

All the components in the Model 410-A are of the highest quality and should have a long trouble-free life since they are operated well below their manufacturer's rating. However, in the course of time some trouble may arise. The following procedure may facilitate locating the source of trouble if the Oscillator does not function properly.

A 2-Ampere (Slo-Blo) cartridge fuse, located in the back of the chassis, is used in the primary circuit of the power transformer to protect the power supply components from short circuits. The rating of this fuse was selected for proper protection of the instrument and should be replaced with the same type and rating. If a fuse failure is detected the following should be checked carefully to determine the cause of the failure before replacing the fuse.

- (a) Check for a faulty rectifier tube 5V4-(V29).
- (b) Short circuits in the filter condensers, C601 and C602, used in the unregulated portion of the power supply can best be detected by connecting an ohmmeter across the terminals directly. See Figure 3 for their location.
- (c) Two electronically regulated power supplies are used in the Model 410-A to provide +185 volts and -185 volts with respect to the chassis or ground. One convenient test point for the +185

volts is the cathode of the 6AS7, V30 (pins #3 and #6). A convenient test point for the -185 volts is the negative side of C601 and C602. If a short to ground exists on either regulated voltage buss, check all the tie points connected to it.

- (d) The DC resistance of the Power Transformer primary should be 1.6 ohms. A much lower resistance probably indicates a shorted primary.

The likeliest source of failure is the vacuum tubes since they have an inherently shorter life. Check first to see if all the tubes are inserted securely in the sockets. Although each tube is rigidly clamped to the chassis it is possible they were loosened in shipment. At the same time note if each tube's filament is lit and that the voltage reference tube (5651) is functioning properly as indicated by a pink glow at the base of the tube. If the unit then fails to operate properly and the correct plate and heater supply voltages are present, check the possibility of a faulty tube. Obtain a new 12AU7, 12AX7, 12AT7, 6AQ5, and 6AL5 and then one at a time, substitute the new tube in each position in the Oscillator where it is used. The location of each vacuum tube is clearly marked on the chassis adjacent to the tube. In most cases, one of these substitutions will affect a cure. If, however, this approach does not succeed a more detailed test must be made. Location of components to check can be facilitated by reference to the schematic Figure 5 and the terminal board layouts, Figure 6, Figure 7, Figure 8, and Figure 9, which show the locations of all the circuit components. In addition Figure 10, provides a vacuum tube voltage chart which gives the correct operating voltage on every pin of each tube. Any appreciable discrepancy between the exist-

ing voltage as measured and the correct one as shown in Figure 10, should be investigated fully.

SERVICE

KROHN-HITE instruments are designed and manufactured in accordance with sound engineering practices, and are guaranteed to give long trouble-free service under normal operating conditions. If your Oscillator fails to provide satisfactory service and you are unable to locate the source of trouble, write to our Service Department giving all the information available concerning the failure. Do not return the instrument without our written authorization for in most cases we will be able to supply you with the information necessary to repair the Oscillator and thus avoid the transportation problems and costs. When it becomes necessary to return the instrument to our factory kindly pack it carefully and ship it to us via express, prepaid.

WARRANTY

KROHN-HITE instruments are conservatively designed to provide continuous reliable service under normal laboratory conditions. The material and workmanship in every instrument is guaranteed for one year from the date of purchase. Any instrument developing defects during this period will be repaired or defective parts will be replaced without charge when the failure is the result of defective material or workmanship. Our warranty does not apply to vacuum tubes.

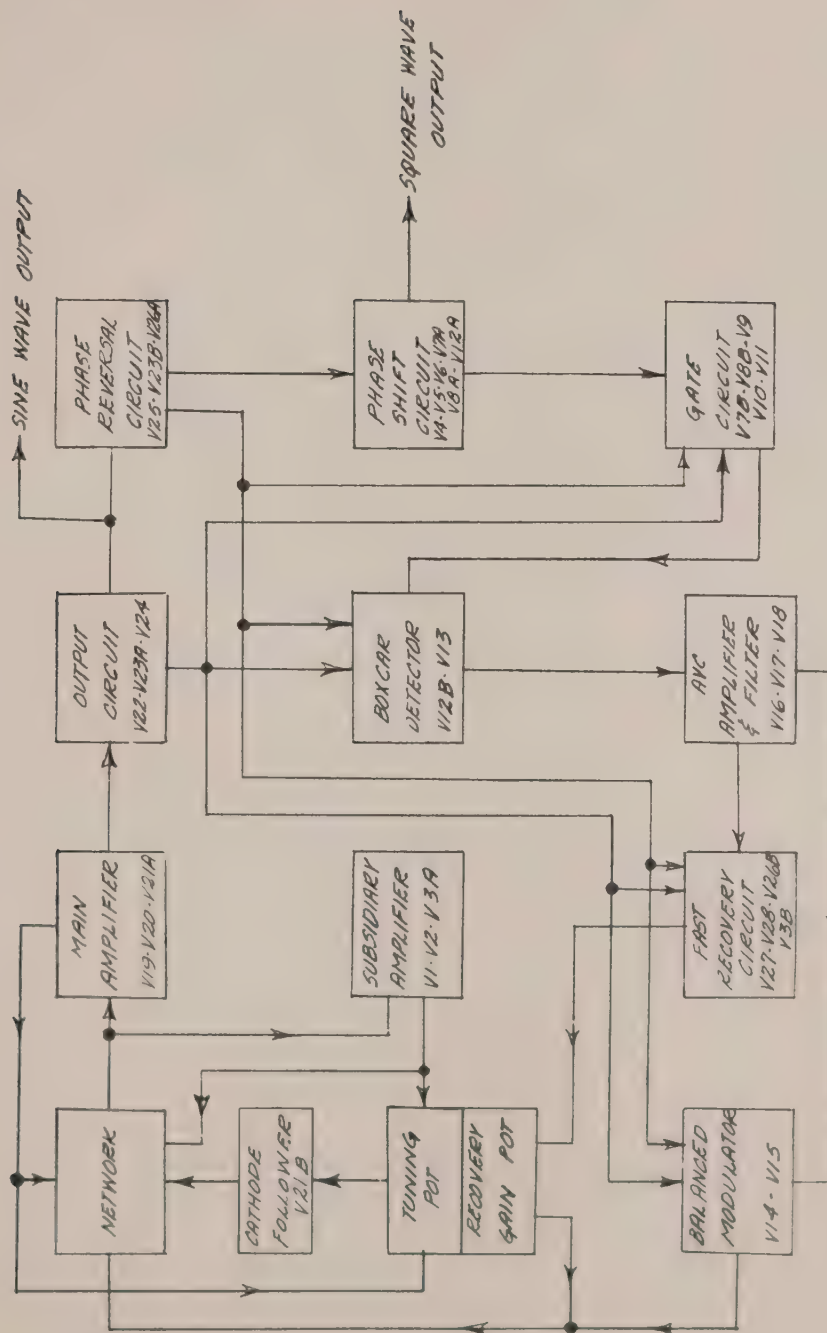


FIGURE 2 - MODEL 410-A BLOCK DIAGRAM

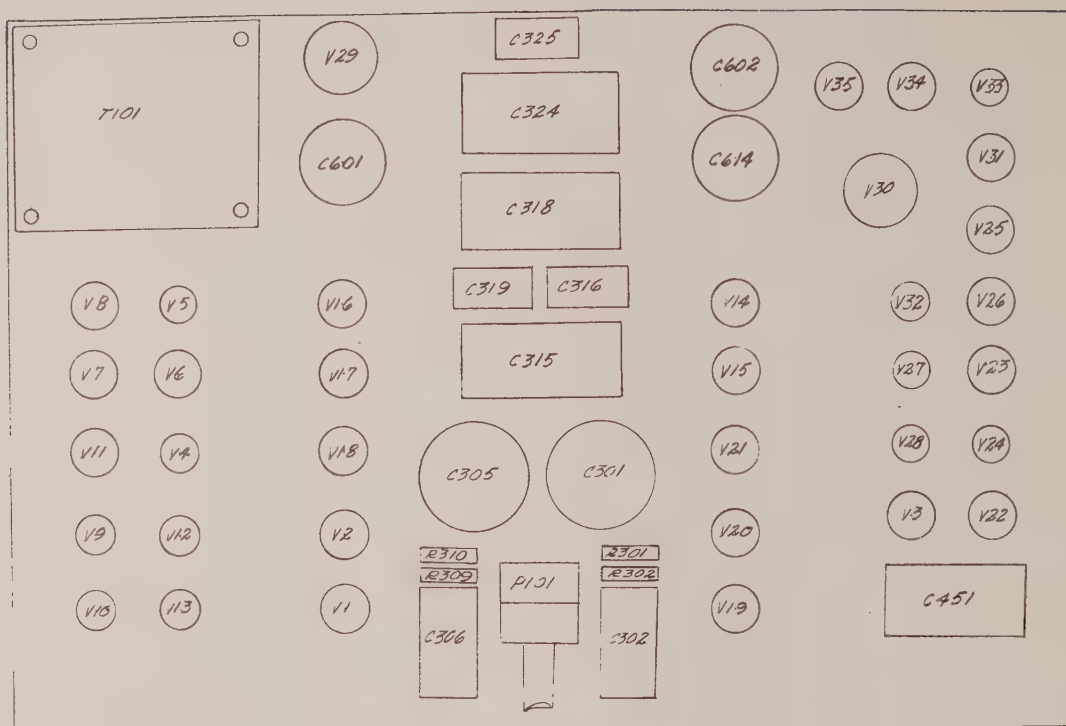


FIGURE 3 - TOP VIEW OF CHASSIS

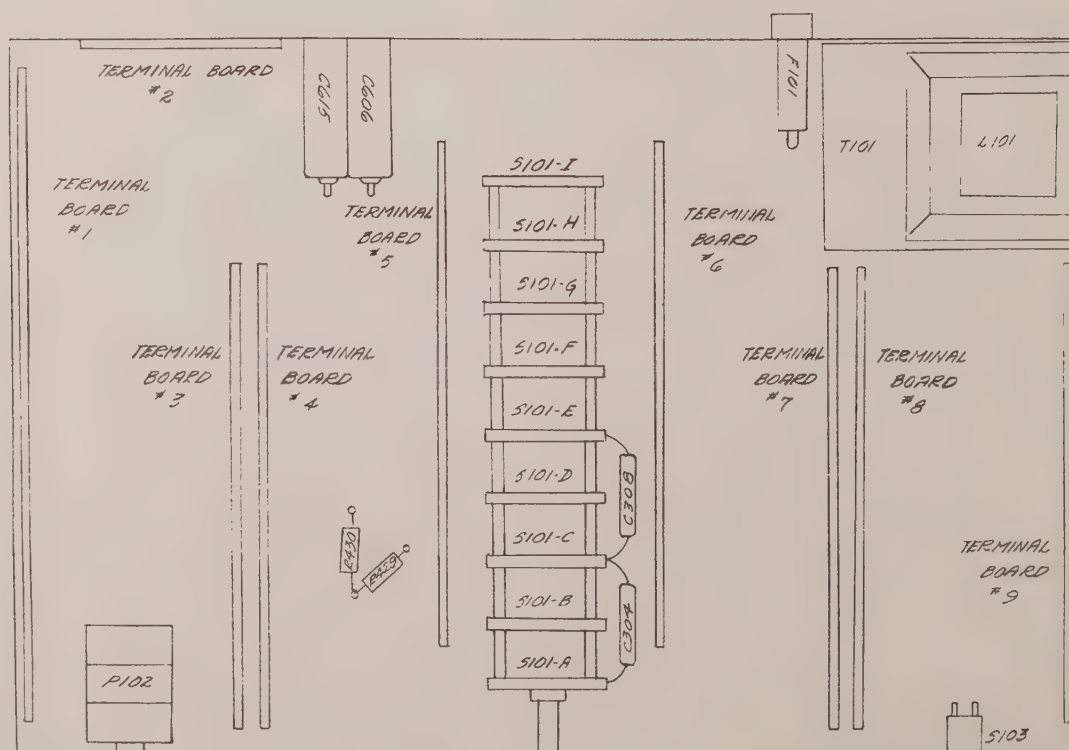
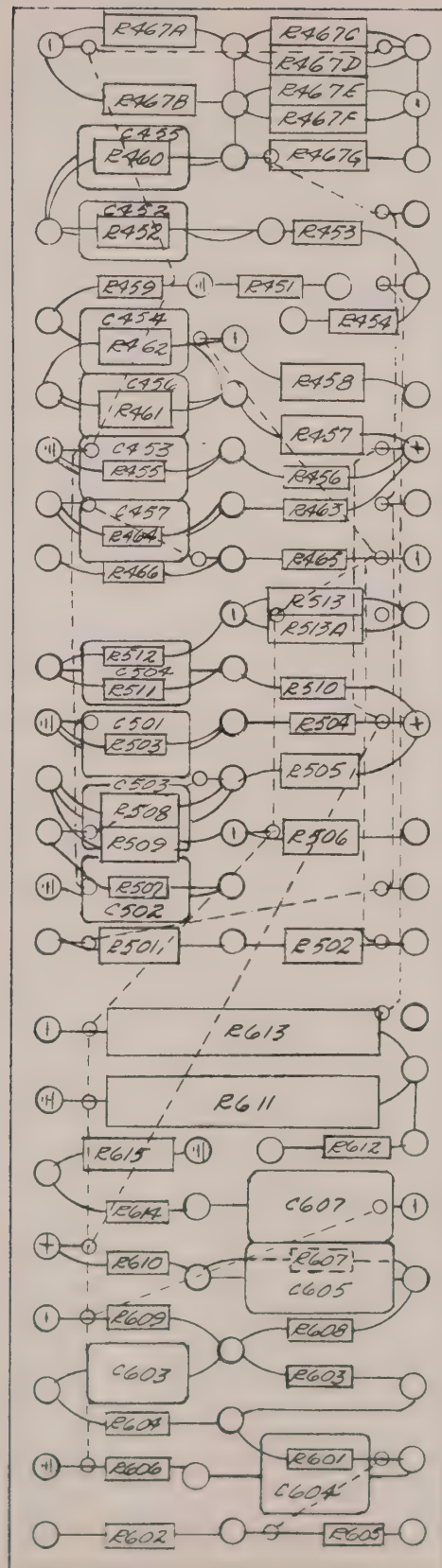
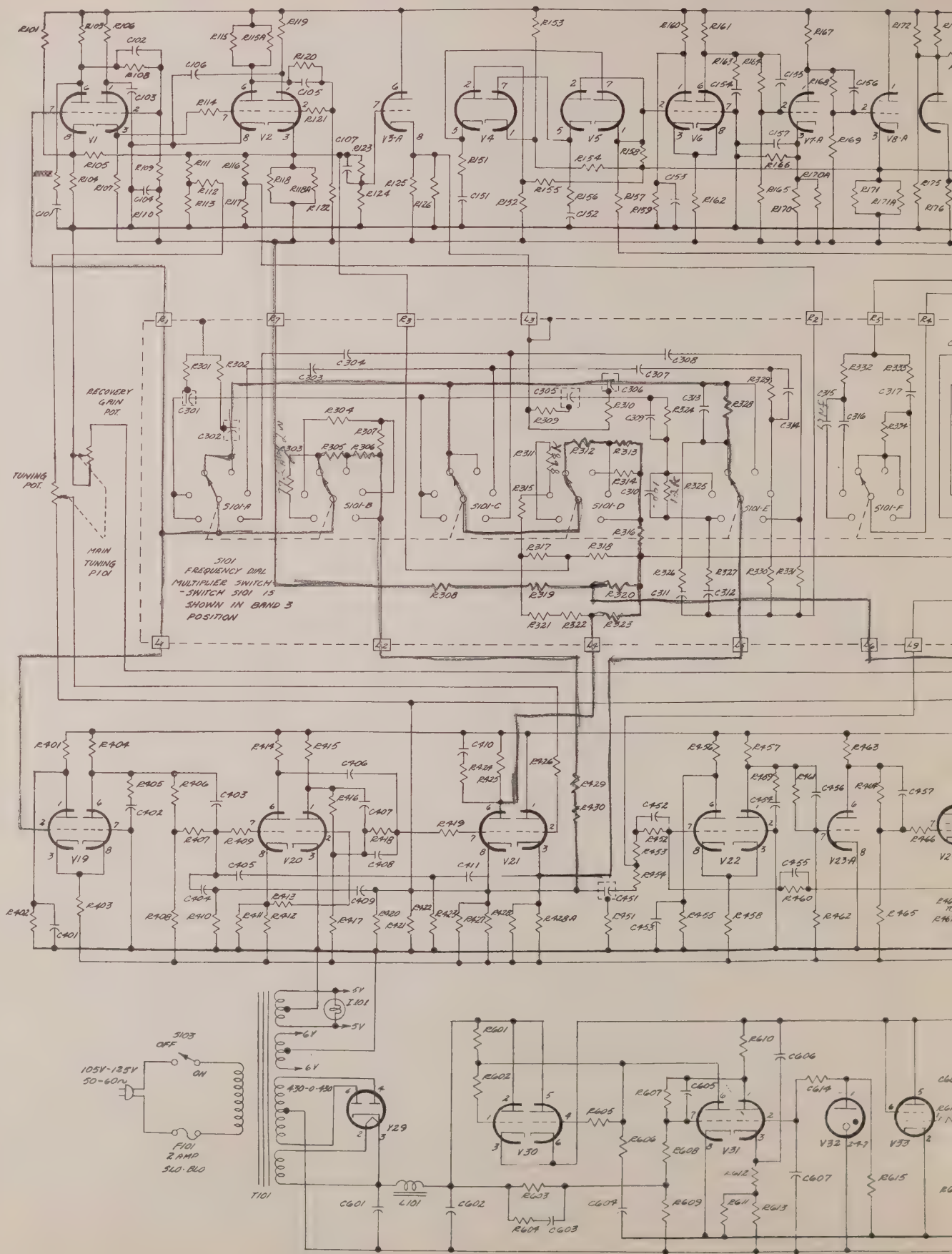


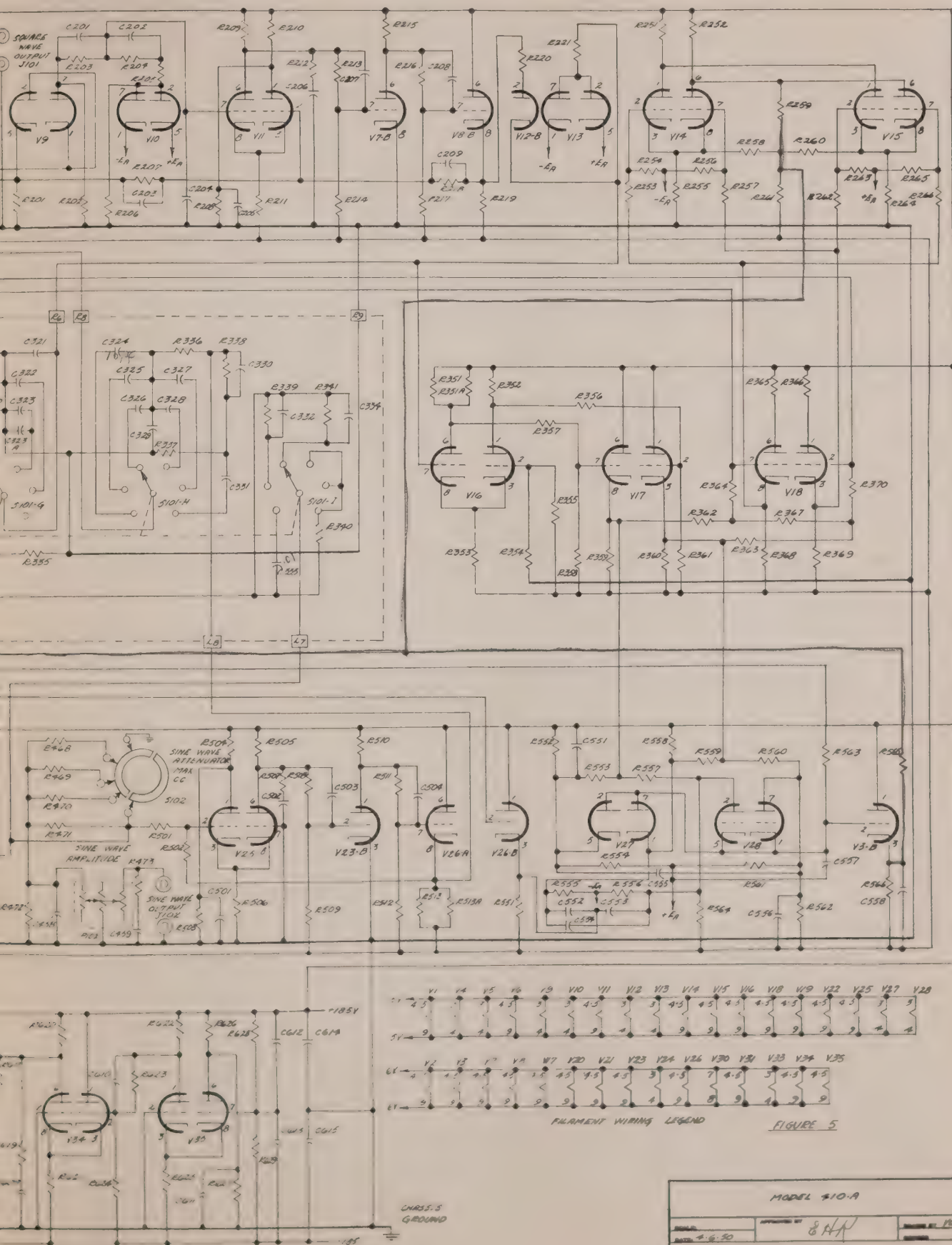
FIGURE 4 - BOTTOM VIEW OF CHASSIS



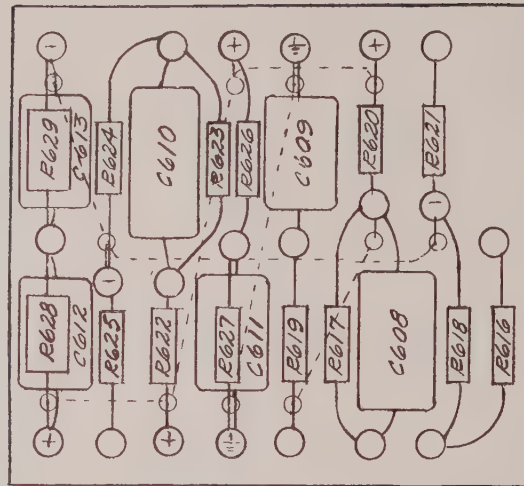
Board 1

FIGURE 6 - TERMINAL BOARD LAYOUT

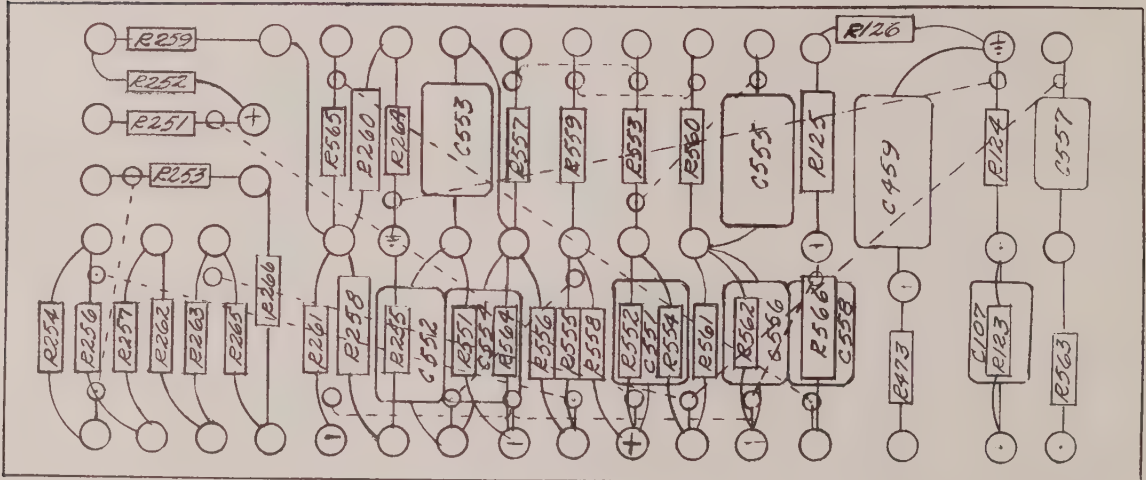




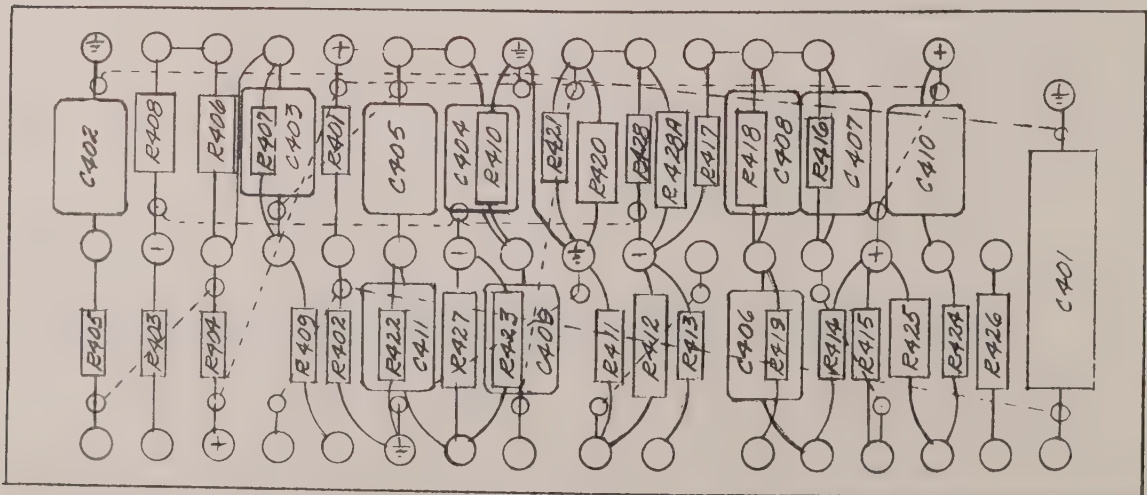
MODEL 410-A	
APPROVED BY	DATE: 4-6-50
SCHEMATIC	
WIDE BAND ULTRA LOW FREQUENCY OSCILLATOR	
GEORGE W. WHITE INSTRUMENT CO.	
CAMBRIDGE, MASS. U.S.A.	
D-410A-1	



Board 2



Board 3



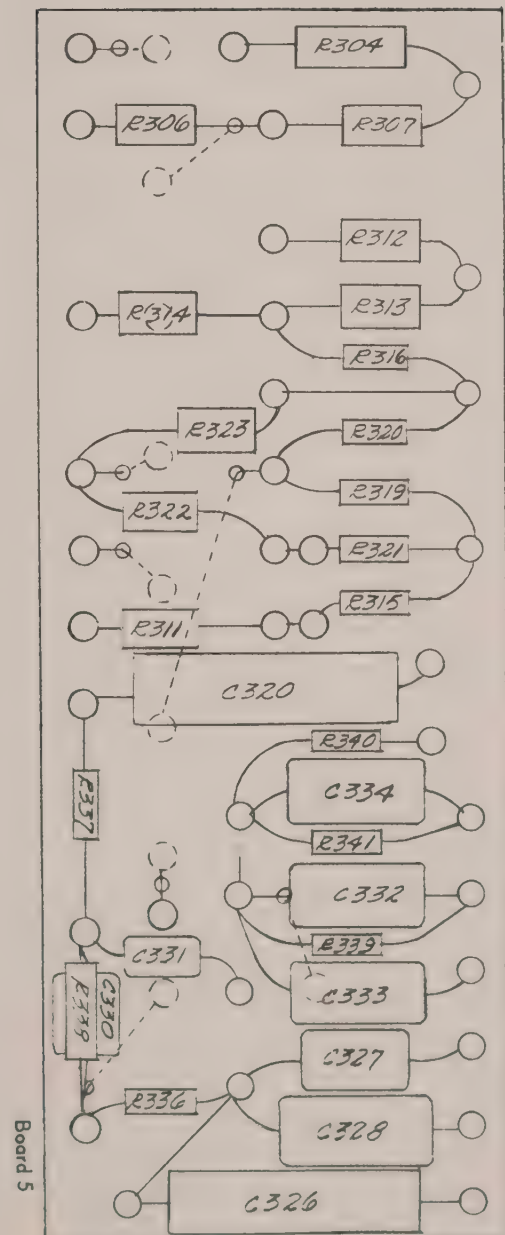
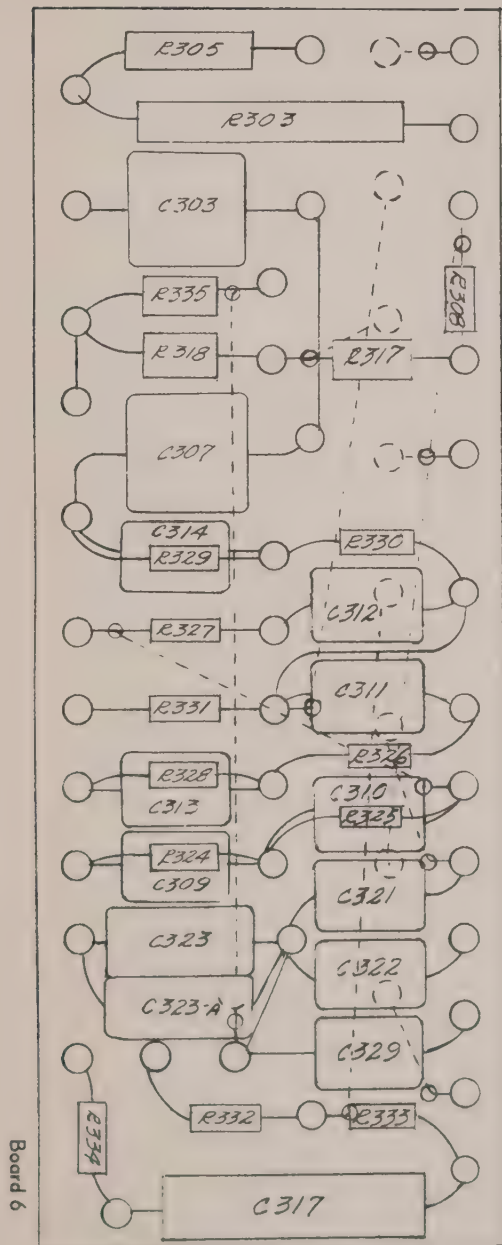
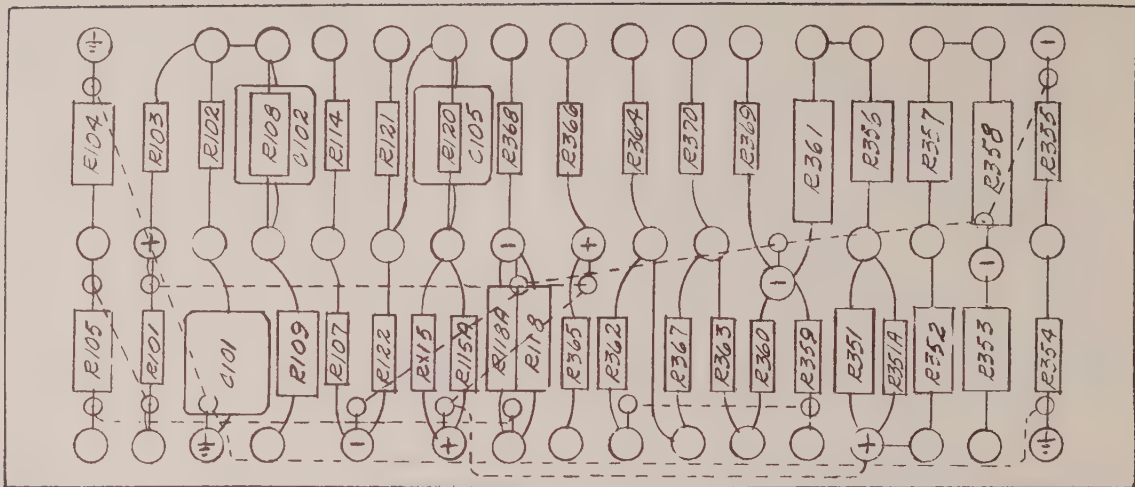
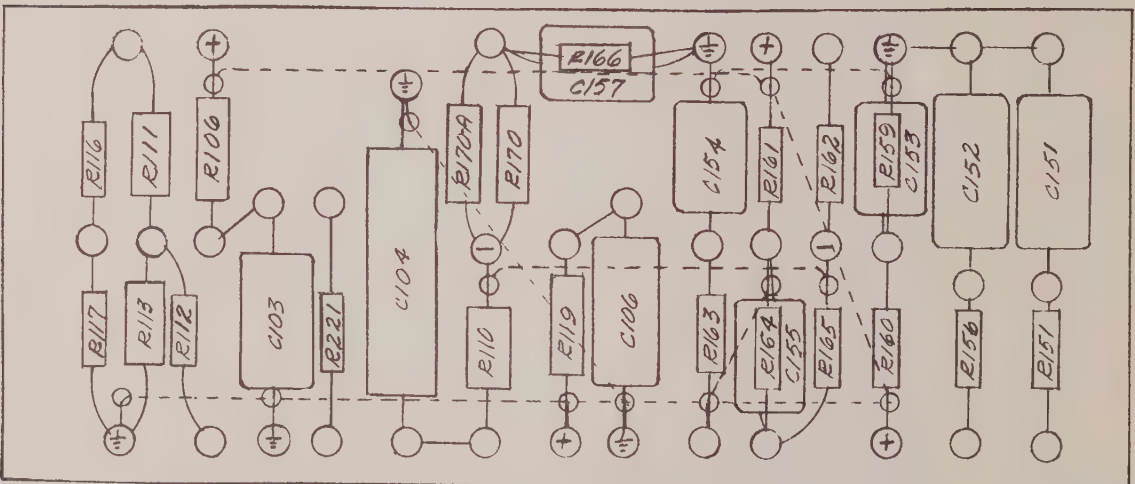


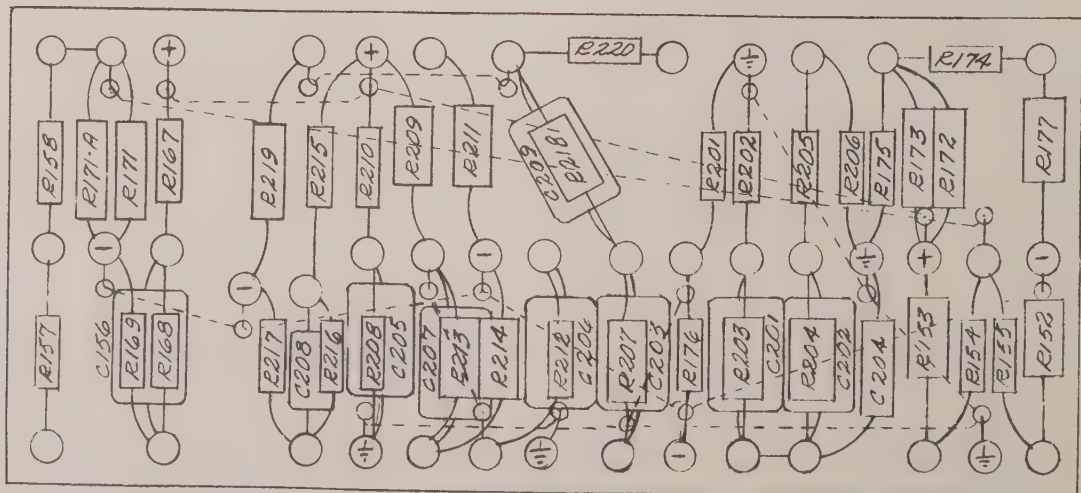
FIGURE 8 - TERMINAL BOARD LAYOUT



Board 7



Board 8



VACUUM TUBE SOCKET VOLTAGES

FREQUENCY DIAL AT 2 ON BAND 5

DC Voltages are measured to ground with 20,000 ohms/volt voltmeter.

Line Voltage 115 volts. W... 2.5 Volts AC. Y... 3 Volts AC.

TUBE NO.	TUBE TYPE	P I N N U M B E R								
		1	2	3	4	5	6	7	8	9
V 1	12AX7	+135	--	-.2±1	W	W	+130	0±.5	+1±1	W
V 2	12AT7	+170	-1.8±1	-.4±.7	Y	Y	+135	--	0	Y
V 3	12AT7	+185	0	+1.2±.5	Y	Y	+185	-.3±.5	+1.8±1	Y
V 4	6AL5	+20±5	-20±5	W	W	-.3±.5	--	+.3±.5	--	--
V 5	6AL5	0±.5	0±.5	W	W	+.3±.5	--	-.3±.5	--	--
V 6	12AX7	+120	-1.1±.3	+1±.5	W	W	+120	0	+1±.5	W
V 7	12AX7	+115	-29	-28	Y	Y	+62±10	-.2±1	0	Y
V 8	12AU7	+185	-1±.5	0±.3	Y	Y	+185	-30	-27	Y
V 9	6AL5	0±.3	0±.3	W	W	+10±2	--	-11±2	--	--
V10	6AL5	0±.2	-8	W	W	0±.2	--	-8	--	--
V11	12AX7	+120	-9	-8	W	W	+120	-9	-8	W
V12	6AL5	+10	-27	W	W	-14	--	+5	--	--
V13	6AL5	0±.2	-14	W	W	0±.2	--	-14	--	--
V14	12AU7	+145	+1±3	+8	W	W	+140	+1±3	+8	W
V15	12AU7	+145	+1±3	+8	W	W	+140	+1±3	+8	W
V16	12AX7	+95	-14	-13	W	W	+95	-14	-13	W
V17	12AU7	+185	-5±10	+1±10	Y	Y	+185	-5±10	+1±10	Y
V18	12AX7	+90	--	+1±5	W	W	+90	--	+1±5	W
V19	12AX7	+120	0±.5	+1±1	W	W	+120	0	+1±1	W
V20	12AT7	+135	-1.5±.5	0	Y	Y	+183	--	-1.5±.5	Y
V21	12AT7	+185	0±.5	+1±1	Y	Y	+180	-2±2	0±.5	Y
V22	12AX7	+120	0	+1±.5	W	W	+120	0±.2	+1±.5	W
V23	12AX7	+110	-1±.5	0	Y	Y	+110	-1±.5	0	Y
V24	6AQ5	-10±5	0±.2	Y	Y	+185	+185	-10±5	--	--
V25	12AX7	+120	0±.2	+1±.5	W	W	+120	0	+1±.5	W
V26	12AU7	+185	0±.5	+10±5	Y	Y	+185	-7±2	0±.2	Y
V27	6AL5	+17±5	0	W	W	+14±5	--	0	--	--
V28	6AL5	0	-18±5	W	W	0	--	-16±5	--	--
V29	5V4	+295	+310	--	-185	--	-185	--	+310	--
V30	6AS7	+135	+295	+185	+135	+295	+185	Y	Y	--
V31	12AX7	+100	--	-95	Y	Y	+135	-1.2	0	Y
V32	5651(VR)	-100	-185	--	-185	-100	--	-185	--	--
V33	6AQ5	-13±5	0	Y	Y	+185	+185	-13±5	--	--
V34	12AX7	+185	--	+1±.5	Y	Y	+100	0	+1±.5	Y
V35	12AX7	+120	0	+1.2±.5	Y	Y	+120	--	+1.2±.5	Y

FIGURE 10

COMPONENTS PARTS LIST

Circuit Number	DESCRIPTION	Circuit Number	DESCRIPTION
R101	220,000 ohms $\frac{1}{2}$ W $\pm$ 5%	R171A	56,000 ohms 1 W $\pm$ 10%
R102	1,500 ohms $\frac{1}{2}$ W $\pm$ 20%	R172	56,000 ohms 1 W $\pm$ 5%
R103	220,000 ohms $\frac{1}{2}$ W $\pm$ 5%	R173	82,000 ohms 1 W $\pm$ 5%
R104	3,000 ohms $\frac{1}{2}$ W $\pm$ 1%	R174	3,300 ohms $\frac{1}{2}$ W $\pm$ 5%
R105	1,700 ohms $\frac{1}{2}$ W $\pm$ 1%	R175	3,300 ohms $\frac{1}{2}$ W $\pm$ 5%
R106	56,000 ohms $\frac{1}{2}$ W $\pm$ 10%	R176	56,000 ohms 1 W $\pm$ 5%
R107	220,000 ohms $\frac{1}{2}$ W $\pm$ 20%	R177	100,000 ohms 1 W $\pm$ 5%
R108	1,200,000 ohms $\frac{1}{2}$ W $\pm$ 1%	R201	12,000 ohms $\frac{1}{2}$ W $\pm$ 10%
R109	1,200,000 ohms $\frac{1}{2}$ W $\pm$ 1%	R202	12,000 ohms $\frac{1}{2}$ W $\pm$ 10%
R110	510,000 ohms $\frac{1}{2}$ W $\pm$ 5%	R203	90,000 ohms $\frac{1}{2}$ W $\pm$ 1%
R111	300 ohms $\frac{1}{2}$ W $\pm$ 1%	R204	90,000 ohms $\frac{1}{2}$ W $\pm$ 1%
R112	33 ohms $\frac{1}{2}$ W $\pm$ 20%	R205	1,500 ohms $\frac{1}{2}$ W $\pm$ 20%
R113	600 ohms $\frac{1}{2}$ W $\pm$ 1%	R206	12,000 ohms $\frac{1}{2}$ W $\pm$ 10%
R114	100 ohms $\frac{1}{2}$ W $\pm$ 20%	R207	220,000 ohms $\frac{1}{2}$ W $\pm$ 1%
R115	12,000 ohms $\frac{1}{2}$ W $\pm$ 10%	R208	1,200,000 ohms $\frac{1}{2}$ W $\pm$ 10%
R115A	12,000 ohms $\frac{1}{2}$ W $\pm$ 10%	R209	220,000 ohms $\frac{1}{2}$ W $\pm$ 1%
R116	1,500 ohms $\frac{1}{2}$ W $\pm$ 10%	R210	220,000 ohms $\frac{1}{2}$ W $\pm$ 5%
R117	2,700 ohms $\frac{1}{2}$ W $\pm$ 10%	R211	480,000 ohms $\frac{1}{2}$ W $\pm$ 1%
R118	56,000 ohms 1 W $\pm$ 10%	R212	12,000 ohms $\frac{1}{2}$ W $\pm$ 10%
R118A	56,000 ohms 1 W $\pm$ 10%	R213	1,200,000 ohms $\frac{1}{2}$ W $\pm$ 1%
R119	3,900 ohms 1 W $\pm$ 10%	R214	1,800,000 ohms $\frac{1}{2}$ W $\pm$ 1%
R120	1,800,000 ohms $\frac{1}{2}$ W $\pm$ 10%	R215	220,000 ohms $\frac{1}{2}$ W $\pm$ 20%
R121	100 ohms $\frac{1}{2}$ W $\pm$ 20%	R216	1,300,000 ohms $\frac{1}{2}$ W $\pm$ 5%
R122	2,400,000 ohms $\frac{1}{2}$ W $\pm$ 5%	R217	1,800,000 ohms $\frac{1}{2}$ W $\pm$ 5%
R123	1,500 ohms $\frac{1}{2}$ W $\pm$ 10%	R218	220,000 ohms $\frac{1}{2}$ W $\pm$ 1%
R124	2,700 ohms $\frac{1}{2}$ W $\pm$ 10%	R219	100,000 ohms 1 W $\pm$ 20%
R125	220,000 ohms 1 W $\pm$ 20%	R220	1,500 ohms $\frac{1}{2}$ W $\pm$ 20%
R126	12,000 ohms $\frac{1}{2}$ W $\pm$ 10%	R221	4,700 ohms $\frac{1}{2}$ W $\pm$ 20%
R151	2,700 ohms $\frac{1}{2}$ W $\pm$ 10%	R251	12,000 ohms $\frac{1}{2}$ W $\pm$ 5%
R152	90,000 ohms $\frac{1}{2}$ W $\pm$ 1%	R252	12,000 ohms $\frac{1}{2}$ W $\pm$ 5%
R153	90,000 ohms $\frac{1}{2}$ W $\pm$ 1%	R253	12,000 ohms $\frac{1}{2}$ W $\pm$ 5%
R154	12,000 ohms $\frac{1}{2}$ W $\pm$ 5%	R254	220,000 ohms $\frac{1}{2}$ W $\pm$ 5%
R155	12,000 ohms $\frac{1}{2}$ W $\pm$ 5%	R255	3,000 ohms $\frac{1}{2}$ W $\pm$ 5%
R156	2,700 ohms $\frac{1}{2}$ W $\pm$ 10%	R256	220,000 ohms $\frac{1}{2}$ W $\pm$ 5%
R157	2,700 ohms $\frac{1}{2}$ W $\pm$ 10%	R257	12,000 ohms $\frac{1}{2}$ W $\pm$ 5%
R158	18,000,000 ohms $\frac{1}{2}$ W $\pm$ 10%	R258	56,000 ohms $\frac{1}{2}$ W $\pm$ 5%
R159	1,200,000 ohms $\frac{1}{2}$ W $\pm$ 10%	R259	110,000 ohms $\frac{1}{2}$ W $\pm$ 5%
R160	220,000 ohms $\frac{1}{2}$ W $\pm$ 5%	R260	56,000 ohms $\frac{1}{2}$ W $\pm$ 5%
R161	220,000 ohms $\frac{1}{2}$ W $\pm$ 5%	R261	110,000 ohms $\frac{1}{2}$ W $\pm$ 5%
R162	510,000 ohms $\frac{1}{2}$ W $\pm$ 5%	R262	12,000 ohms $\frac{1}{2}$ W $\pm$ 5%
R163	3,900 ohms $\frac{1}{2}$ W $\pm$ 10%	R263	220,000 ohms $\frac{1}{2}$ W $\pm$ 5%
R164	1,800,000 ohms $\frac{1}{2}$ W $\pm$ 5%	R264	3,000 ohms $\frac{1}{2}$ W $\pm$ 5%
R165	1,800,000 ohms $\frac{1}{2}$ W $\pm$ 5%	R265	220,000 ohms $\frac{1}{2}$ W $\pm$ 5%
R166	4,700 ohms $\frac{1}{2}$ W $\pm$ 10%	R266	12,000 ohms $\frac{1}{2}$ W $\pm$ 5%
R167	330,000 ohms $\frac{1}{2}$ W $\pm$ 10%	R301	220,000 ohms $\frac{1}{2}$ W $\pm$ 20%
R168	5,100,000 ohms $\frac{1}{2}$ W $\pm$ 5%	R302	220,000 ohms $\frac{1}{2}$ W $\pm$ 20%
R169	8,200,000 ohms $\frac{1}{2}$ W $\pm$ 5%	R303	77,200,000 ohms 2 W $\pm$ 1%
R170	56,000 ohms 1 W $\pm$ 10%	R304	7,270,000 ohms $\frac{1}{2}$ W $\pm$ 1%
R170A	56,000 ohms 1 W $\pm$ 10%		
R171	56,000 ohms 1 W $\pm$ 10%		

COMPONENTS PARTS LIST

Circuit Number	DESCRIPTION	Circuit Number	DESCRIPTION
R305	23,200,000 ohms 1 W $\pm$ 1%	R363	510,000 ohms $\frac{1}{2}$ W $\pm$ 5%
R306	1,550,000 ohms $\frac{1}{2}$ W $\pm$ 1%	R364	18,000,000 ohms $\frac{1}{2}$ W $\pm$ 10%
R307	2,000,000 ohms $\frac{1}{2}$ W $\pm$ 1%	R365	510,000 ohms $\frac{1}{2}$ W $\pm$ 5%
R308	750,000 ohms $\frac{1}{2}$ W $\pm$ 5%	R366	510,000 ohms $\frac{1}{2}$ W $\pm$ 5%
R309	220,000 ohms $\frac{1}{2}$ W $\pm$ 20%	R367	1,200,000 ohms $\frac{1}{2}$ W $\pm$ 5%
R310	220,000 ohms $\frac{1}{2}$ W $\pm$ 20%	R368	1,200,000 ohms $\frac{1}{2}$ W $\pm$ 10%
R311	868,000 ohms $\frac{1}{2}$ W $\pm$ 1%	R369	1,200,000 ohms $\frac{1}{2}$ W $\pm$ 10%
R312	51,000 ohms $\frac{1}{2}$ W $\pm$ 1%	R370	18,000,000 ohms $\frac{1}{2}$ W $\pm$ 10%
R313	6,200 ohms $\frac{1}{2}$ W $\pm$ 1%		
R314	2,920 ohms $\frac{1}{2}$ W $\pm$ 1%	R401	220,000 ohms $\frac{1}{2}$ W $\pm$ 5%
R315	22,000 ohms $\frac{1}{2}$ W $\pm$ 20%	R402	1,200,000 ohms $\frac{1}{2}$ W $\pm$ 10%
R316	220 ohms $\frac{1}{2}$ W $\pm$ 20%	R403	510,000 ohms $\frac{1}{2}$ W $\pm$ 5%
R317	119,000 ohms $\frac{1}{2}$ W $\pm$ 1%	R404	220,000 ohms $\frac{1}{2}$ W $\pm$ 5%
R318	4,480 ohms $\frac{1}{2}$ W $\pm$ 1%	R405	470 ohms $\frac{1}{2}$ W $\pm$ 20%
R319	510,000 ohms $\frac{1}{2}$ W $\pm$ 5%	R406	1,200,000 ohms $\frac{1}{2}$ W $\pm$ 1%
R320	36,000 ohms $\frac{1}{2}$ W $\pm$ 5%	R407	18,000,000 ohms $\frac{1}{2}$ W $\pm$ 10%
R321	0-20,000 ohms Trimmer	R408	1,800,000 ohms $\frac{1}{2}$ W $\pm$ 1%
R322	725,000 ohms $\frac{1}{2}$ W $\pm$ 1%	R409	100 ohms $\frac{1}{2}$ W $\pm$ 20%
R323	111,600 ohms $\frac{1}{2}$ W $\pm$ 1%	R410	56,000 ohms $\frac{1}{2}$ W $\pm$ 10%
R324	1,000 ohms $\frac{1}{2}$ W $\pm$ 20%	R411	2,700 ohms $\frac{1}{2}$ W $\pm$ 10%
R325	12,000 ohms $\frac{1}{2}$ W $\pm$ 10%	R412	100,000 ohms 1 W $\pm$ 20%
R326	22,000 ohms $\frac{1}{2}$ W $\pm$ 20%	R413	100 ohms $\frac{1}{2}$ W $\pm$ 20%
R327	2,700 ohms $\frac{1}{2}$ W $\pm$ 20%	R414	1,500 ohms $\frac{1}{2}$ W $\pm$ 20%
R328	2,200 ohms $\frac{1}{2}$ W $\pm$ 20%	R415	12,000 ohms $\frac{1}{2}$ W $\pm$ 10%
R329	470 ohms $\frac{1}{2}$ W $\pm$ 20%	R416	1,800,000 ohms $\frac{1}{2}$ W $\pm$ 10%
R330	220,000 ohms $\frac{1}{2}$ W $\pm$ 20%	R417	2,400,000 ohms $\frac{1}{2}$ W $\pm$ 5%
R331	220,000 ohms $\frac{1}{2}$ W $\pm$ 20%	R418	56,000 ohms $\frac{1}{2}$ W $\pm$ 10%
R332	1,800,000 ohms $\frac{1}{2}$ W $\pm$ 10%	R419	100 ohms $\frac{1}{2}$ W $\pm$ 20%
R333	470,000 ohms $\frac{1}{2}$ W $\pm$ 20%	R420	5,380 ohms $\frac{1}{2}$ W $\pm$ 1%
R334	1,200,000 ohms $\frac{1}{2}$ W $\pm$ 10%	R421	47,000-330,000 ohms Trimmer
R335	11,100 ohms $\frac{1}{2}$ W $\pm$ 1%	R422	12,000 ohms $\frac{1}{2}$ W $\pm$ 10%
R336	2,700 ohms $\frac{1}{2}$ W $\pm$ 20%	R423	100,000 ohms $\frac{1}{2}$ W $\pm$ 20%
R337	22,000 ohms $\frac{1}{2}$ W $\pm$ 20%	R424	6,800 ohms $\frac{1}{2}$ W $\pm$ 10%
R338	56,000 ohms $\frac{1}{2}$ W $\pm$ 10%	R425	760 ohms $\frac{1}{2}$ W $\pm$ 1%
R339	1,800,000 ohms $\frac{1}{2}$ W $\pm$ 10%	R426	100 ohms $\frac{1}{2}$ W $\pm$ 20%
R340	470,000 ohms $\frac{1}{2}$ W $\pm$ 20%	R427	56,000 ohms 1 W $\pm$ 10%
R341	470,000 ohms $\frac{1}{2}$ W $\pm$ 20%	R428	56,000 ohms 1 W $\pm$ 10%
		R428A	56,000 ohms 1 W $\pm$ 10%
R351	480,000 ohms $\frac{1}{2}$ W $\pm$ 1%	R429	511,600 ohms $\frac{1}{3}$ W $\pm$ 1%
R351A	10,000,000 ohms $\frac{1}{2}$ W $\pm$ 10%	R430	511,600 ohms $\frac{1}{3}$ W $\pm$ 1%
R352	480,000 ohms $\frac{1}{2}$ W $\pm$ 1%		
R353	527,000 ohms $\frac{1}{2}$ W $\pm$ 1%	R451	220,000 ohms $\frac{1}{2}$ W $\pm$ 20%
R354	12,000 ohms $\frac{1}{2}$ W $\pm$ 5%	R452	3,950,000 ohms $\frac{1}{2}$ W $\pm$ 1%
R355	150,000 ohms $\frac{1}{2}$ W $\pm$ 10%	R453	220,000 ohms $\frac{1}{2}$ W $\pm$ 20%
R356	5,700,000 ohms $\frac{1}{2}$ W $\pm$ 1%	R454	22,000 ohms $\frac{1}{2}$ W $\pm$ 20%
R357	5,700,000 ohms $\frac{1}{2}$ W $\pm$ 1%	R455	1,200,000 ohms $\frac{1}{2}$ W $\pm$ 10%
R358	9,000,000 ohms $\frac{1}{2}$ W $\pm$ 1%	R456	220,000 ohms $\frac{1}{2}$ W $\pm$ 5%
R359	620,000 ohms $\frac{1}{2}$ W $\pm$ 5%	R457	220,000 ohms $\frac{1}{2}$ W $\pm$ 1%
R360	560,000 ohms $\frac{1}{2}$ W $\pm$ 5%	R458	480,000 ohms $\frac{1}{2}$ W $\pm$ 1%
R361	9,000,000 ohms $\frac{1}{2}$ W $\pm$ 1%	R459	470 ohms $\frac{1}{2}$ W $\pm$ 20%
R362	510,000 ohms $\frac{1}{2}$ W $\pm$ 5%	R460	9,000,000 ohms $\frac{1}{2}$ W $\pm$ 1%

COMPONENTS PARTS LIST

Circuit Number	DESCRIPTION	Circuit Number	DESCRIPTION
R461	1,200,000 ohms $\frac{1}{2}$ W $\pm$ 1%	R607	1,200,000 ohms $\frac{1}{2}$ W $\pm$ 10%
R462	1,800,000 ohms $\frac{1}{2}$ W $\pm$ 1%	R608	1,800,000 ohms $\frac{1}{2}$ W $\pm$ 10%
R463	220,000 ohms $\frac{1}{2}$ W $\pm$ 20%	R609	220,000 ohms $\frac{1}{2}$ W $\pm$ 20%
R464	1,300,000 ohms $\frac{1}{2}$ W $\pm$ 5%	R610	220,000 ohms $\frac{1}{2}$ W $\pm$ 10%
R465	1,800,000 ohms $\frac{1}{2}$ W $\pm$ 5%	R611	3,000 ohms 5 W $\pm$ 5%
R466	100 ohms $\frac{1}{2}$ W $\pm$ 20%	R612	1,500 ohms $\frac{1}{2}$ W $\pm$ 20%
R467A-G	56,000 ohms 1 W $\pm$ 10%	R613	2,700 ohms 5 W $\pm$ 5%
R468	2,000 ohms 1 W $\pm$ 1%	R614	470,000 ohms $\frac{1}{2}$ W $\pm$ 20%
R469	2,500 ohms $\frac{1}{2}$ W $\pm$ 1%	R615	56,000 ohms 1 W $\pm$ 10%
R470	11,100 ohms $\frac{1}{2}$ W $\pm$ 1%	R616	100 ohms $\frac{1}{2}$ W $\pm$ 20%
R471	100,000 ohms $\frac{1}{2}$ W $\pm$ 1%	R617	1,200,000 ohms $\frac{1}{2}$ W $\pm$ 10%
R472	1,000 ohms $\frac{1}{2}$ W $\pm$ 1%	R618	1,800,000 ohms $\frac{1}{2}$ W $\pm$ 10%
R501	12,000 ohms $\frac{1}{2}$ W $\pm$ 1%	R619	22,000 ohms $\frac{1}{2}$ W $\pm$ 20%
R502	12,000 ohms $\frac{1}{2}$ W $\pm$ 1%	R620	220,000 ohms $\frac{1}{2}$ W $\pm$ 10%
R503	1,200,000 ohms $\frac{1}{2}$ W $\pm$ 10%	R621	110,000 ohms $\frac{1}{2}$ W $\pm$ 5%
R504	220,000 ohms $\frac{1}{2}$ W $\pm$ 5%	R622	220,000 ohms $\frac{1}{2}$ W $\pm$ 5%
R505	220,000 ohms $\frac{1}{2}$ W $\pm$ 1%	R623	1,200,000 ohms $\frac{1}{2}$ W $\pm$ 5%
R506	480,000 ohms $\frac{1}{2}$ W $\pm$ 1%	R624	1,800,000 ohms $\frac{1}{2}$ W $\pm$ 5%
R507	470 ohms $\frac{1}{2}$ W $\pm$ 20%	R625	510,000 ohms $\frac{1}{2}$ W $\pm$ 5%
R508	1,200,000 ohms $\frac{1}{2}$ W $\pm$ 1%	R626	220,000 ohms $\frac{1}{2}$ W $\pm$ 5%
R509	1,800,000 ohms $\frac{1}{2}$ W $\pm$ 1%	R627	1,200,000 ohms $\frac{1}{2}$ W $\pm$ 10%
R510	220,000 ohms $\frac{1}{2}$ W $\pm$ 20%	R628	527,000 ohms $\frac{1}{2}$ W $\pm$ 1%
R511	1,200,000 ohms $\frac{1}{2}$ W $\pm$ 10%	R629	527,000 ohms $\frac{1}{2}$ W $\pm$ 1%
R512	1,800,000 ohms $\frac{1}{2}$ W $\pm$ 10%	C101	51 μ f 500 V $\pm$ 20%
R513	56,000 ohms 1 W $\pm$ 10%	C102	10 μ f 500 V $\pm$ 20%
R513A	56,000 ohms 1 W $\pm$ 10%	C103	0.01 μ f 400 V $\pm$ 20%
R551	220,000 ohms $\frac{1}{2}$ W $\pm$ 20%	C104	0.1 μ f 400 V $\pm$ 20%
R552	680,000 ohms $\frac{1}{2}$ W $\pm$ 5%	C105	10 μ f 500 V $\pm$ 20%
R553	100,000 ohms $\frac{1}{2}$ W $\pm$ 5%	C106	0.01 μ f 400 V $\pm$ 20%
R554	110,000 ohms $\frac{1}{2}$ W $\pm$ 5%	C107	220 μ f 500 V $\pm$ 20%
R555	110,000 ohms $\frac{1}{2}$ W $\pm$ 5%	C151	0.01 μ f 400 V $\pm$ 20%
R556	110,000 ohms $\frac{1}{2}$ W $\pm$ 5%	C152	0.01 μ f 400 V $\pm$ 20%
R557	110,000 ohms $\frac{1}{2}$ W $\pm$ 5%	C153	1,000 μ f 500 V $\pm$ 20%
R558	510,000 ohms $\frac{1}{2}$ W $\pm$ 5%	C154	220 μ f 500 V $\pm$ 20%
R559	110,000 ohms $\frac{1}{2}$ W $\pm$ 5%	C155	220 μ f 500 V $\pm$ 20%
R560	100,000 ohms $\frac{1}{2}$ W $\pm$ 5%	C156	220 μ f 500 V $\pm$ 20%
R561	110,000 ohms $\frac{1}{2}$ W $\pm$ 5%	C157	1,000 μ f 500 V $\pm$ 20%
R562	510,000 ohms $\frac{1}{2}$ W $\pm$ 5%	C201	150 μ f 500 V $\pm$ 5%
R563	470 ohms $\frac{1}{2}$ W $\pm$ 20%	C202	100 μ f 500 V $\pm$ 5%
R564	470,000 ohms $\frac{1}{2}$ W $\pm$ 5%	C203	24 μ f 500 V $\pm$ 5%
R565	6,800 ohms $\frac{1}{2}$ W $\pm$ 10%	C204	50 μ f 500 V $\pm$ 5%
R566	220,000 ohms $\frac{1}{2}$ W $\pm$ 20%	C205	1,000 μ f 500 V $\pm$ 20%
R601	470,000 ohms $\frac{1}{2}$ W $\pm$ 20%	C206	220 μ f 500 V $\pm$ 20%
R602	100 ohms $\frac{1}{2}$ W $\pm$ 20%	C207	220 μ f 500 V $\pm$ 20%
R603	8,200,000 ohms $\frac{1}{2}$ W $\pm$ 10%	C208	10 μ f 500 V $\pm$ 20%
R604	1,800,000 ohms $\frac{1}{2}$ W $\pm$ 10%	C209	24 μ f 500 V $\pm$ 5%
R605	100 ohms $\frac{1}{2}$ W $\pm$ 20%	C301	1 μ f 100 V $\pm$ 10%
R606	4,700 ohms $\frac{1}{2}$ W $\pm$ 20%		

COMPONENTS PARTS LIST

Circuit Number	DESCRIPTION	Circuit Number	DESCRIPTION
C302	0.08 μf 100 V $\pm$ 1%	C455	3.9 μf 500 V $\pm$ 10%
C303	8,200 μf 300 V $\pm$ 1%	C456	220 μf 500 V $\pm$ 20%
C304	2,400 μf 500 V $\pm$ 1%	C457	1,000 μf 500 V $\pm$ 20%
C305	1 μf 100 V $\pm$ 10%	C458	1,000 μf 500 V $\pm$ 20%
C306	0.08 μf 100 V $\pm$ 1%	C459	5,000 μf 400 V $\pm$ 20%
C307	4,300 μf 500 V $\pm$ 1%		
C308	1,300 μf 500 V $\pm$ 1%	C501	1,000 μf 500 V $\pm$ 20%
C309	1,000 μf 500 V $\pm$ 20%	C502	220 μf 500 V $\pm$ 20%
C310	1,000 μf 500 V $\pm$ 20%	C503	220 μf 500 V $\pm$ 20%
C311	1,000 μf 500 V $\pm$ 20%	C504	1,000 μf 500 V $\pm$ 20%
C312	1,000 μf 500 V $\pm$ 20%		
C313	2,000 μf 500 V $\pm$ 20%	C551	1,000 μf 500 V $\pm$ 20%
C314	220 μf 500 V $\pm$ 20%	C552	2,000 μf 500 V $\pm$ 20%
C315	10 μf 200 V $\pm$ 20%	C553	2,000 μf 500 V $\pm$ 20%
C316	1 μf 400 V $\pm$ 20%	C554	2,000 μf 500 V $\pm$ 20%
C317	0.1 μf 400 V $\pm$ 20%	C555	0.01 μf 400 V $\pm$ 20%
C318	10 μf 200 V $\pm$ 20%	C556	1,000 μf 500 V $\pm$ 20%
C319	1 μf 400 V $\pm$ 20%	C557	3 μf 500 V $\pm$ 10%
C320	0.1 μf 400 V $\pm$ 20%	C558	10 μf 500 V $\pm$ 20%
C321	1,000 μf 500 V $\pm$ 20%		
C322	2,000 μf 500 V $\pm$ 20%	C601	4 μf 600 V $\pm$ 20%
C323	0.01 μf 400 V $\pm$ 20%	C602	4 μf 600 V $\pm$ 20%
C323A	0.01 μf 400 V $\pm$ 20%	C603	1,000 μf 500 V $\pm$ 20%
C324	10 μf 200 V $\pm$ 20%	C604	2,000 μf 500 V $\pm$ 20%
C325	1 μf 400 V $\pm$ 20%	C605	0.01 μf 400 V $\pm$ 20%
C326	0.1 μf 400 V $\pm$ 20%	C606	1 μf 400 V $\pm$ 20%
C327	1,000 μf 500 V $\pm$ 20%	C607	0.01 μf 400 V $\pm$ 20%
C328	0.01 μf 400 V $\pm$ 20%	C608	0.01 μf 400 V $\pm$ 20%
C329	470 μf 500 V $\pm$ 20%	C609	220 μf 400 V $\pm$ 20%
C330	220 μf 500 V $\pm$ 20%	C610	0.01 μf 400 V $\pm$ 20%
C331	100 μf 500 V $\pm$ 20%	C611	1,000 μf 500 V $\pm$ 20%
C332	0.01 μf 400 V $\pm$ 20%	C612	1,000 μf 500 V $\pm$ 20%
C333	0.01 μf 400 V $\pm$ 20%	C613	1,000 μf 500 V $\pm$ 20%
C334	0.01 μf 400 V $\pm$ 20%	C614	4 μf 600 V $\pm$ 20%
		C615	1 μf 400 V $\pm$ 20%
C401	0.1 μf 400 V $\pm$ 20%		
C402	24 μf 500 V $\pm$ 20%	V1	12AX7
C403	39 μf 500 V $\pm$ 10%	V2	12AT7
C404	39 μf 500 V $\pm$ 10%	V3	12AX7
C405	24 μf 500 V $\pm$ 10%	V4	6AL5
C406	10 μf 500 V $\pm$ 10%	V5	6AL5
C407	1,000 μf 500 V $\pm$ 20%	V6	12AX7
C408	15 μf 500 V $\pm$ 10%	V7	12AX7
C409	5 μf 500 V $\pm$ 10%	V8	12AU7
C410	2,000 μf 500 V $\pm$ 20%	V9	6AL5
C411	100 μf 500 V $\pm$ 20%	V10	6AL5
		V11	12AX7
C451	10 μf 200 V $\pm$ 20%	V12	6AL5
C452	10 μf 500 V $\pm$ 5%	V13	6AL5
C453	1,000 μf 500 V $\pm$ 20%	V14	12AU7
C454	220 μf 500 V $\pm$ 20%	V15	12AU7

COMPONENTS PARTS LIST

Circuit Number	DESCRIPTION	Circuit Number	DESCRIPTION
V16	12AX7	F-101	1¼" Fuse Holder 3AG
V17	12AU7	I-101	Bayonet 6.3 V @ .15 A
V18	12AX7	L-101	7-8 H 100 ohms @ .150 A
V19	12AX7	P-101	Dual 50,000 ohms Clocklog
V20	12AT7	P-102	T-pad 500 ohms
V21	12AT7	S-101	SP6P-9 Gang Rotary
V22	12AX7	S-102	2P4P Rotary
V23	12AX7	S-103	SPST Toggle
V24	6AQ5	T-101	PRIMARY: 115 V, 50-60 CPS SECONDARY: 430-0-430 V @ .125 A 5 V @ 2 A 5 V @ 5.5 A CT 6.3 V @ 7.5 A CT
V25	12AX7		
V26	12AU7		
V27	6AL5		
V28	6AL5		
V29	5V4		
V30	6AS7		
V31	12AX7		
V32	5651(VR)		
V33	6AQ5		
V34	12AX7		
V35	12AX7		

www.manualsplus.com



1001000